Chapter 4.5

People with Special Needs and Service Access

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1. Introduction

The conceptual framework for usage of telecommunications services described in Chapter 1 includes the parameter 'user'. The inclusion of this parameter would suggest that there are differences between users that could influence the design of a service. More generally, there could be differences between human users that could have an influence on many elements of the telecommunications system. The purpose of this chapter is to show that these differences are real and significant, and that the numbers of people involved are significant and therefore represent important potential markets.

To do this, the ability of people to see clearly without refractive sight errors will be discussed, as this is a condition that is recognised and accepted within the general population. The data shows, however, that the impression of this condition is perhaps different from the truth.

Following this, the special needs of particular users seeking to make use of telecommunications facilities are explained. This is followed by a discussion showing the location of points in the system where problems for these users may occur.

Having recognised that there might be problems for some users, some principles are given to assist designers in avoiding these problems. These will allow measures to be taken to accommodate the special needs of those users where integration is potentially difficult.

2. Profile of a Human User

2.1 Typical Human Performance Distributions

One of the most interesting properties of human beings is that they vary one from the other. It does not take children very long to learn to distinguish between people. They then learn to characterise people into groups qualified by labels such as big, middle sized and tiny. They learn to tell the difference between Mother and Father, and brother and sister.

Although this ability is so readily exercised by children, it is interesting to notice that as adults we tend to try to equalise the differences between people for political, idealistic or engineering reasons, whilst preserving their differences for marketing purposes.

Before focussing on the characteristics of so called People with Special Needs, it would be valuable to be reminded of some of those of the entire population.

People are often described as belonging to people groups, based upon regions of origin. This method of classification has the merit that it depends on two readily discernible attributes: Physical appearance and language. With increasing dispersion of people groups within cosmopolitan populations the characteristics, particularly that of language, become intermixed or substituted. The root physical differences result in populations with a wide variance in obvious physical characteristics, including height, fatness (or thinness), facial features, strength, agility etc.

These physical differences are accompanied by variance in the intellectual ability across the population, variances in temperament and emotional responses, and perhaps most importantly differences in functional ability. If a class of children being tested for athletic ability is considered these difference become immediately obvious.

The interesting aspect of this simple analysis, however, is that the notion of considering differences in the population when engineering is preserved for a few domains such as the design of the driving controls of a car (and even then principally in the more expensive models). Very little concession for this is made in the case of consumer electronics, nor in the design of a working environment where applied ergonomics is still considered something of a luxury.

Having become used to being able to live with both recognising fundamental differences between members of the population, and being able to readily ignore those differences, it seems that the most logical way of accommodating the implications of these differences is to class those for whom they are important as either minority groups or the handicapped.

One of the most interesting exceptions is the case of visual impairment. The correction of visual impairment has been freely accepted since the early part of the twentieth century, although the possible use of ground corrective lenses has been understood since classical times and available (without papal disapproval!) since the foundational scientific work of Roger Bacon in 1276 was taken up during the Renaissance. The manufacture, selling, fitting and especially marketing of spectacles and contact lenses is a huge business. The spectacles themselves becoming part of the overall image of the wearer, and the complaint directed against them is generally concerning the inconvenience rather than the fact that they are a symbol of the wearer's disability.

What is additionally surprising is the range of impairments that are corrected in this way, the mildness of the conditions for which correction is considered necessary, and the distribution and variance of the conditions within the population as a whole. In order to illustrate this, the examples of the two most common refractive errors (ametropias) that degrade perfect vision (emmetropia) could be considered: Myopia or short-sightedness and hypermetropia or long-sightedness.

As can be seen from figure 1 below, perfect vision (emmetropia) is enjoyed by a minority of the population, with about half suffering from long-sight of some degree, and about one in six from short-sight. The significant aspect of the figure is that it challenges our pre-conceived notions of distributions and age related trends (although it is fair to say the no distinction is made within these three coarse groupings to cover situations corrected by for example bi-focal lenses.)

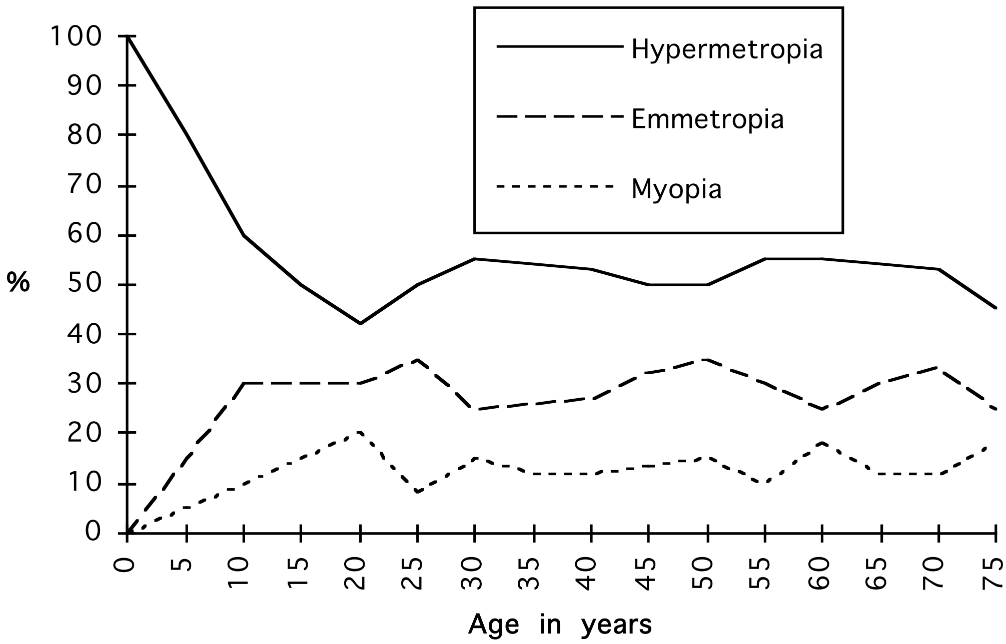

Figure 1: The relative frequency of hypermetropia, emmetropia and myopia as age advances (after Duke-Elder)

In terms of the population of Europe, this gives the following approximate numbers of people in the three groups.

	Percentage of Pop.	Numbers

Total European Population		322,356,000
People with emmetropia	30	96,706,800
People with myopia	15	48,353,400
People with hypermetropia	55	177,295,800

Table 1 - Populations of people in Europe, including those with refractive error conditions affecting their sight.

It is worth emphasising the variance aspect of these conditions with the following quote (Trevor-Roper). 'Among humans the proportions of myopes and hypermetropes are surprisingly constant in nearly all the Western races, 15 to 20 per cent being myopic and about 50 per cent hypermetropic; but in China and Japan myopia is about four times as common (60 to 70 per cent). Semitic races are also prone to myopia, often of high degree, while this is very rarely found among Nubians. The prevalence of high myopia in Egyptians and Jews as opposed to other Caucasians, in other Europeans as opposed to Eskimos and African Negros, in Brahmins as opposed to non-Brahmins, has been attributed to their longer histories of civilisation, the laws of natural selection (that would tend to weed out the less competitive high myopes in a primitive society) being relaxed in civilised groups.' Whilst the explanation may not be empirical, the data is notable.

The value of this short and crude analysis is that it reveals that there is a difference in the available data and general perception in a number of key areas:

- Refractive errors are a clinical condition which cause a functional impairment, causing a disability which may handicap the person in some situations
- These conditions are not, however, considered as impairments, or those who have them as disabled, a fact assisted by the fact that they have popular names
- Those who have these conditions often publicly display the fact with corrective devices that proclaim it
- Over two thirds of a western population suffer from these conditions

These conditions have the unusual characteristic that the method of correction is one that is socially acceptable and straightforward (ie cheap!). In contrast, however, the distribution of hearing affecting conditions within a population follow a similar pattern, but the willingness of sufferers to admit to and deal with it is completely different, and the decay of hearing ability is still considered a disabling condition.

To complete the argument developed above, it is possible to add further numbers to those given in Table 1 to show data governing the edges of the distribution. These numbers have two important attributes. Firstly, they give a spread to the performance distribution, showing that there is a flattening of the distribution curve away from a clear majority average peak towards that of a flatter distribution where the probability of a member of the population having perfect or even mean vision is reduced. The second attribute is that the numbers of people towards the edges of the distribution are not insignificant.

This argument could be continued by introducing additional functional abilities into the population distribution. The probability of a member of the population having perfect sight *and* perfect hearing is lower than that of having perfect ability in just one of the areas. If all the abilities that will be required for utilisation of a multimedia telecommunications service/terminal are considered, the probability of perfection becomes increasingly small.

This is not a problem if the distribution of functional ability has a fairly steep peak. This means that whilst few people have perfect sight, most have good sight. Repeat this across all the functional abilities and an average human user is described, which fits most of the population.

This argument has the problem that it is not altogether clear as to what functional ability is considered 'good enough' when a part of the system is being designed. The correlation between 'good enough' and proportion of the population is likely to be surprisingly small if the example of sight is extrapolated across the range of functional abilities required. This would lead to the conclusion, therefore, that the range of abilities on any dimension across a majority of the population is wider than is initially or intuitively recognised.

The important truth is that the distribution of any human ability is a significant, and the idea of average ability is (largely because of its age dependent nature) impossible to quantify, and highly misleading and therefore useless.

As far as human factors and engineering is concerned, the important engineering constraint is not the average Human User, but the size and ability variance of the target population. For this reason, the attribute 'User' in the Reference for User Service outlined in the introduction, is a fundamental component. The attributes of the user are a significant characteristic that determines the value of a number of the other attributes. It would be fundamentally inappropriate to design a service from the perspective of the technological possibilities that the system offers without first considering the attributes and therefore the operational or functional abilities of the user.

2.2 Characteristics of People with Special Needs

The value of considering the functional ability of human users as a distribution of ability against the population is that provides an insight into the ease with which people along the distribution are going to find in using the particular parts of the system that depend on that ability. It is clear that the further that the user is away from the centre of the distribution, the more difficulty he will encounter. The flatter the distribution, the less people there are at the centre as a proportion of the population, and therefore the greater the number of people that will experience difficulties.

As people encounter difficulties, they have need for some help to overcome the problem. The greater the difficulty, the greater the need. This therefore introduces the concepts of 'People with Special Needs', which could be defined, in the context of use of a telecommunications system, as a Human User whose functional ability in one or more of the relevant areas is towards the edges of the ability/population distribution, and who as a result needs help when this ability is required to use the system.

This definition is perhaps rather vague, but this is intentional, as it exposes the most important attributes of this group of users. Firstly, this is not a distinct group of people at all, but, because people have a degree of need the further they are away from the centre of the distribution, the need is a continuum from no need to significant need. The second point is that the need may arise, to varying degrees, because of more than one non-perfect functional ability. As has been argued above, because the ability/population distribution is predictably quite flat if all functional abilities are considered, many users could be predicted to encounter difficulties, but the areas that they are encountering difficulties in may be quite diverse.

This analysis would not be complete without a discussion about cause. This is not only because it might help in the identification of appropriate solutions, but also in order to dispel some of the prejudices and myths that abound in discussions over this topic, and focus on the truth and the real issues.

So far, need has only been identified as resulting from a user have non-perfect ability in a particular functional area. This lack of ability has been illustrated by an example resulting from a physical condition. This is, however, far from the only cause, and it is important to list some of the others:-

- Immaturity - Lack of development of functional ability
- Lack of training - eg. Relevant language skill, lack of training opportunity.
- Lack of mental functionality - Includes cognitive processing skills, memory etc.
- Loss of functional ability - Caused by accident, illness or trauma.
- Decay of functional ability - Caused by progression of illness or age

Whilst this list is not complete, it contains enough detail to show that causes are diverse and may be mixed, compounding the potential problem. In addition, in a Pan-European context, assumptions about language or even compatible life experience (important in the chosing intuitive metaphors and icons) cannot be guaranteed.

Having said this, the focus of work in RACE has concentrated on the users for whom problems may be anticipated because of the impairments that they have as a result of aging or of a disability.

2.2.1 Definitions

Before going on to discuss the practical aspects of special needs, it is important to give the definition of some commonly used terms. The starting point will be to apply the definitions given by the World Health Organisation of impairment, disability and handicap

- Impairment, concerned with abnormalities of body structure and appearance and with organ or system functions, resulting from any cause; in principle, impairments represent disturbances at the organ level.
- Disabilities, reflecting the consequences of impairment in terms of functional performance and activity by the individual; disabilities thus represent disturbances at the level of the person.
- Handicaps, concerned with the disadvantages experienced by the individual as a result of impairments and disabilities; handicaps thus reflect interaction with and adaptation to the individual's surroundings.

The important point about these definitions is that they represent different degrees of severity or consequence. This means that a potential cause may or may not result in an impairment, an impairment may or may not result in a disability and a disability may or may not result in a handicap.

The consequence of this is that many people may have an experience that could result in an impairment, but it only happens for some of them. Of these, only some impairments are disabling, and in these cases, only some give rise to a handicap. This is illustrated in Figure 2.

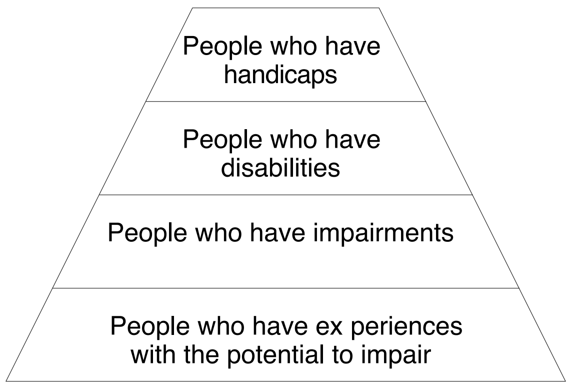

Figure 2: relationship between populations of people with impairments, disabilities and handicaps

Before moving on to consider some specific examples of impairments and disabilities, it is important to remember that the disability and handicap may be situation specific. It does not automatically follow that a person that has a particular impairment is always disabled or handicapped. The impairment causes them to be unable to do something (they are then disabled), but may have no influence on another activity. In the same way, some environments or situations may have nothing in them that is a problem for someone with a particular impairment, whereas others may be effectively a prison for the same person, because they depend heavily on the ability that has been impaired.

2.2.2 Functional Consequences of Impairments and Associated Disabilities

Although there are many ways that a human user may experience impairment, it has been found to be useful to group some of these impairments together in order to isolate the essential elements or affects of the impairment. Example coarse groupings are briefly explained below. These do not follow a standard classification such as that used by the World Health Organisation, but are given in order to illustrate the range of possible conditions that may have an influence on the ability of a human user to benefit from telecommunications.

• *Physical Impairment*

These refer to those impairments that affect the skeleton or the muscle system in such a way as to render the person in some way disabled according to the definition given above. The impairments include the following range.

- Deformed or incomplete skeleton, including oversize or undersize skeleton or parts of the skeleton, and loss of parts of the skeleton.
- Reduced muscle functionality, including muscle wasting and loss of muscles, and loss of control of muscle due to impairment of the nervous system
- Loss of stamina or ability to sustain muscle activity, including such parts as the heart.

• *Sensory Impairment*

These cover those impairments that affect the ability of a user to assimilate stimulus from their surroundings. They include:

- Aural impairments, or those associated with the ears and the hearing system, including partial or total loss of hearing, and loss of part of the hearing frequency range.
- Ocular impairments, or those associated with the eyes and the visual system, including partial or total loss of sight, impairment of colour discrimination, or loss of eyes.
- Haptic sensory impairments or impairments of sense of touch.

• *Intellectual and Psychological Impairment*

These affect the ability of a person to make full use of their intellectual capability, or impair the capability. They include:

- Impairment of cognitive functions, such as development or decay of functions of perception, attention, memory and thinking.
- Impairments of emotive and volitional functions, including such areas as emotional responses, drives and motivations
- Behavioural impairments, including changes in behaviour patterns

• *Language Impairments*

These cover the loss of ability to communicate with language and they include:

- Impairment of language comprehension and use
- Impairment of speech

The reader is referred to the work of RACE project R1088 TUDOR, RACE project R1066 IPSNI and the results of the COST 219 project given in the reference list, for explanations of different impairments and their relevance to the use of telecommunications systems.

Having outlined the principle areas of possible impairments that a human user may experience, it is important to consider that the probability of encountering a user with an impairment is not uniform across the age range of a population. The situation is best described by quoting from the RACE TUDOR deliverable 'Age and Design', where it is stated that '…as age advances, there is a steady increase in the probability of declines away from the optimum performance on nearly all measures of sensory, intellectual and physical function. It is also important to recognise that age changes are not merely quantifiable declines in specific abilities. Rather, changes are multiple, involving many abilities, and typically interactive, in the sense that declines in some abilities may exaggerate the effects of declines in others while, as people grow older, they learn to compensate for skills they lose by finding new ways to deploy the skills they retain.' (Collins and Rabbitt, 1990).

The reader is referred to this volume for further reference on the implications for designing appropriately to meet the needs of the older members of the population. One point that is perhaps worth reiterating is that an important characteristic of these people is that whilst, on average, there is a trend of increasing functional impairment, this trend hides the fact that the average covers a very wide ability range, so designing for the average will make the system totally unusable for some, and trivial for others. It is also important to recognise that these changes begin to become significant from the age of about 45 years, bringing them well within the working age range.

2.2.3 European Populations of People with Special Needs

Because of the potential to design users out of being able to use the telecommunications system, it is important to consider the numbers of people that could be affected. Because of the range of possible abilities and impairments, it may be tempting to consider the problem as too complex, and for this reason to decide to ignore the problem. If, however, it can be demonstrated that there are significant numbers of potential customers being potentially set aside, the market for products that consider the needs of 'non-average' users will seem more attractive and viable.

Demographic work of this kind was undertaken by the RACE TUDOR project and published by Sandhu and Wood for people with special needs in general, and Collins and Rabbitt for elderly people. Some important numbers are given below, but the reader is strongly recommended to refer to the source documents for a more instructive insight.

Type of Impairment	% of Population	Number (Millions)
Physical		
Lower Limb	5.8	18.7
Upper Limb	1.9	6.1
Visual	2.0	6.5
Hearing	2.7	8.7
Mental	2.3	7.4
Verbal Communication	1.1	3.6

Table 2: Population of people with a disability of European Member States

Total European Population = 322,356,000
Disabled Population = 11.3% - 15.1%

Another important set of data covers the trends in population of the elderly

Year	1980	1990	2000	2010	2020	2030	2040	2050
Millions	3.6	3.8	4.1	4.5	4.9	5.5	5.8	5.2
% of Population	13.1	13.6	14.7	16.0	18.1	20.8	22.4	21.6

Table 3: Population aged 65 and over, 1980 - 2050, in the European Community

The clear message from this data is that these numbers are not insignificant, and that they represent an important market opportunity. It is important to remember that in addition to the fact that the number of people aged 65 and over is increasing, the purchasing power of this group of people is also increasing, so they represent a valuable market.

2.3 Potential for integration of People with Special Needs

The final questions to be answered with regard to the need to consider people with special needs when designing telecommunications equipment and services, is whether these people will want to use these systems. In other words, although there is a potential market, is there a demand.

In principle such systems will be found in the working and the domestic environments. It is important to discern whether people with special needs will be found in these environments, and whether such system will be of interest to them.

Following the international year of the disabled in 1982, three movements started which have begun to encourage people with special needs to take up positions of responsibilities in jobs which previously were not considered suitable for them. The first has been a change in the expectation of the people themselves which resulted in a more prevalent belief that they have a contribution to make that is as valuable as any other member of the population. Because of this more and more people with impairments are seeking employment opportunities and the training required to get them. This has been accompanied by a number of fairly effective initiatives within Europe, both at a local and international level, to provide training and employment opportunities for these people. As these have proved successful, employers have been challenged to refocus on the ability of an employee rather than the supposed disability. In addition, due to the demographic imbalance of a growing retired population and a fall in the number of young people joining the workforce, the number of people available for employment has been falling. This means that skilled, available prospective employees are becoming increasingly attractive, regardless of their associated impairments. The opportunities provided by appropriately designed telecommunications equipment and services ensure that functional impairments can often be alleviated or rendered irrelevant, allowing the user to concentrate on the tasks for which they have been employed. The consequence is that the probability that a user of the system will have a special need is not insignificant, a fact which should not be ignored by designers.

This trend towards greater independence has been mirrored across Europe by a move from institutional residence and provision to community care and independent living, prompted by both a desire for greater freedom and integration on the part of the people themselves, and a need to save money in health care budgets by closing residential institutions. This has resulted in an increasing number of people with special needs living in the community and requiring access to their own telecommunications access, both for their own personal recreation or entertainment, and for support and contact with the remote health or support services.

These two factors would tend to indicate that there is a demand by these people, a fact that is supported by the work of RACE project R1088 Tudor, and by the findings of ETSI project team PT6V when they were considering the need for human factors standards for these users. In their final report (soon to be published as an ETSI Technical Report), some specific services were highlighted as being of particular interest to these users, and these services were listed for priority standardisation activity.

2.4 Service design and people with special needs

The conceptual framework discussed in chapter 1 provides a way for the designer to ensure that the issues described in this chapter are considered. From this it should be possible to ensure that the requirements of the user upon the network can be anticipated and provided for, so that the system can be brought into the configuration or state necessary for the user's goal to be achieved. The value is that a method has been devised that proves that the requirements can be met according to a logical and well structured procedure instead of by trial and error, if at all.

The operational requirements stage described in chapter 1 consists of two perspectives, and can be described in an integrated way for a particular application as follows:

Usage Context description	description of application tasks, potential users, performance parameters
RUS definition	allocation of tasks to users, description of required states of users and communication tasks
SUS definition	service attributes for supporting the tasks, nested services for supporting the users
Enabling States Analysis	service features that enable users to undertake their tasks. The work of IPSNI has focussed to a large extent on the accessibility of IBC from the perspective of people with special needs.

This four stage analysis is highly appropriate to ensure that the requirements of people with special needs are taken account of as a matter of course. This will be illustrated in the following paragraphs.

2.4.1 Usage Context description

User characteristics should include the characteristics of *all potential application actors*, not just the so-called 'average users'. This means that the design of the service will take into account the needs of people from right across the distribution of abilities, rather than focussing on a single point in the distribution.

2.4.2 Reference for User Services (RUS)

Task allocation will depend upon user characteristics. For example, the design of the RUS implies user interdependencies and therefore needs to take temporal characteristics into account. Users will vary considerably in the speed with which they can access, process, and respond to information. They will also vary considerably in their ability to handle each information type. Therefore a crucial analysis, which will be used to propose nested services for user support at the SUS stage, is the difference between the actual state of each user and the state that is required for them to execute their task.

2.4.3 Specific User Services (SUS)

At this stage of the analysis, nested services such as help desks, training services and translation services can be proposed to close the gap between the actual and the required states of the users. In addition, service attributes can be chosen so that the specific service is appropriate—for example, audio quality with respect to the hard of hearing, simple service provider dialogues for emergency procedures, and media transformation such as text to speech facilities.

Analysis of the requirements of people with special needs indicates that even basic conversational services are likely to be highly asymmetric in many cases. People with special needs who are unable to use one or more services can be provided with life-transforming (and ultimately, more cost effective) services, e.g. video for sign language, which can help them maintain an independent lifestyle. An illustration of such a case can be found in Chapter 4.1, where an application level generic user service for remote care is described (section 6).

2.4.4 Enabling States Analysis

The relevance of this approach to people with special needs is twofold. Firstly, the enabling state specification is determined by the user's characteristics. The preconditions for an elderly user to successfully carry out a remote transaction with their bank may not be the same as those for a young user. For example, in the latter case the user interface could present several simultaneous tasks, and a quantity of information which may be too much for the elderly user to successfully process.

Secondly, enabling states are created by enabling tasks. Although goal tasks have the user as the agent, enabling tasks need not have. When enabling tasks are allocated to other elements of the system (e.g., the terminal), the dialogue with the service provider becomes simpler for the user. This is the basis for the terminal becoming an intelligent agent for user assistance.

This analysis is relevant to the general issue of accessibility. The next section therefore deals with this in more detail.

3. Accessibility and telecommunications interaction

As has been discussed in 2 above, special needs brought about by disability or age are both very widespread and loosely homogeneous, and at the same time quite specific and difficult to categorise. If any provision is to be made to meet the special needs anticipated by Human Users, it is important to identify why those needs are arising, and where the site of the problems are. For this reason, a very simple argument is developed below to give a crude model that will highlight these issues. From there solutions can be identified. Space does not permit a rigourous analysis. For this the reader is referred to the work of RACE Project R1066 IPSNI, RACE Project R1088 TUDOR, RACE Project R1067 APPSN, COST project 219 and the ETSI technical committee Human Factors

3.1 The interaction cycle and the Human User

In order to focus on the aspects of service design that specifically consider the requirements of people with special needs, a few general aspects need to be discussed. These will simply describe, perhaps from a different position, some ideas that have been described in detail in previous chapters. This applies particularly to the concepts outlined in the introduction to this book. In some cases aspects are represented with a different emphasis, but the link to the introduction will be indicated.

The first aspect to clarify is exactly what user interaction involves. It can be easily recognised that when a human user makes use of the facilities offered by a telecommunication system, they will be required to manipulate a piece of equipment that is functioning as telecommunications terminal. This manipulation will be regulated by the response that they perceive coming from this equipment. The equipment is, however, only the tangible, visible end of a chain of hardware and software enabling access to human and machine communicating entities at the other end(s) of the system. It is therefore clear that the human user will be interacting with elements within the whole system which is terminated by the terminal. In the following discussion, the system will firstly be considered as a whole, and as issues are raised, an attempt will be made to attribute them to an appropriate site within the system so that solutions can be identified.

In order to understand where users with special needs might encounter difficulties as they try to interact with the system, it would be valuable to consider the cycle of actions and system responses that make up a session, and from that begin to introduce the parameters and variables that could affect accessibility. This will show that Human Factors considerations arise at a number of points in the interaction cycle, and they arise for all Human Users. It is important to recognise that the interaction will involve both a dialogue with the system itself, and a communication of information via the system. The cycle is outlined in Figure 3, where the important element of where the interaction is initiated is introduced. This highlights the fact that the Human User may at times be the initiator of cycles in the session, or they may be responding to an event initiated elsewhere in the system. For example, they may initiate a telephone call, or they may respond to a ringing telephone.

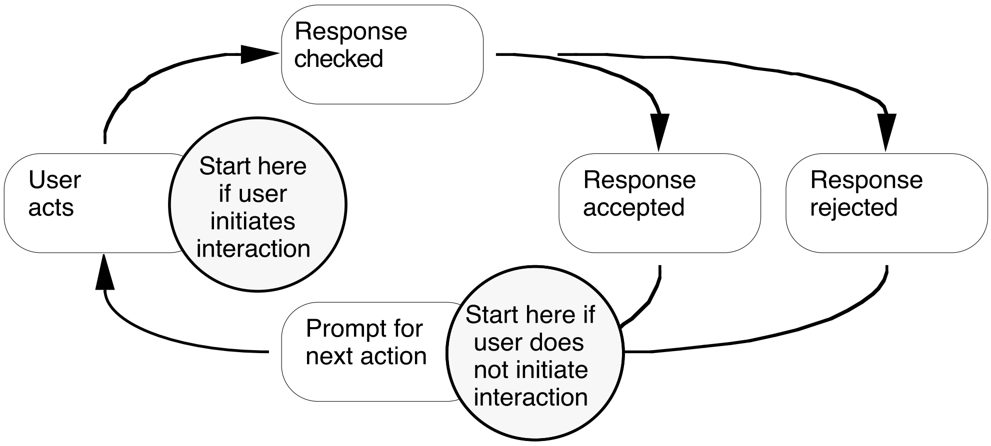

Figure 3: An example of a cycle of Human User/telecommunications interaction

The importance of this distinction is that it demonstrates that the Human User must be able to assimilate the media that is conveying a prompt from the system, and they must be able to convey their own intentions to the system in a media acceptable to the system. Although this may at first seem rather obvious, it does immediately give an idea of the versatility required by a Human User of a multimedia terminal, and begins to point to possible sources of inaccessibility.

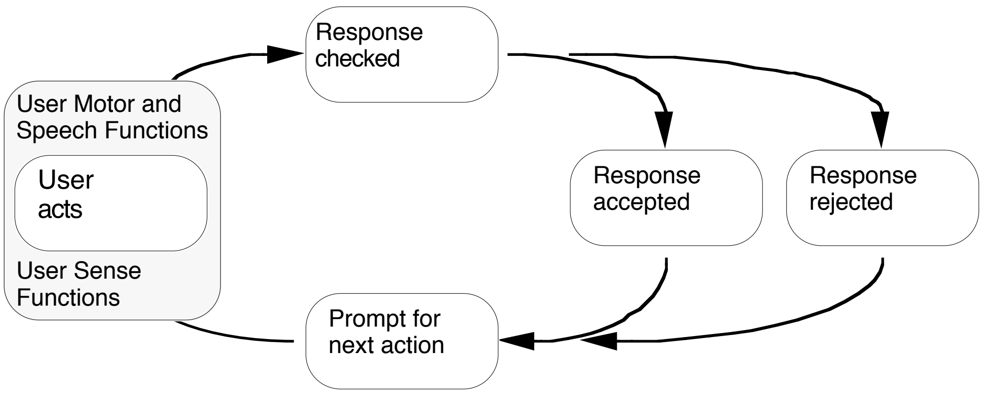

Figure 4: An example of a cycle of Human User/telecommunications interaction and the Human User functionality that are necessary for successful interaction

The situation is further complicated by the fact the user will have a particular goal in mind for which the telecommunications system is the tool that has been chosen to enable this goal to be achieved. In order achieve this goal however, some effort will need to be spent in manipulating the system in order to prepare it to be usable. Although these 'goal tasks' may well be intuitive, the 'enabling tasks', which are peculiar to this particular tool, may well not be.

Both figure 3 and figure 4 give a simple representation of how the interaction between the Human User and the system takes place. They focus primarily on the points in the interaction chain where processes within the system have human factors associated with them. Some examples of the sort of topics that might be covered, and the possible sites where the topics could reside within the system are shown in figure 5.

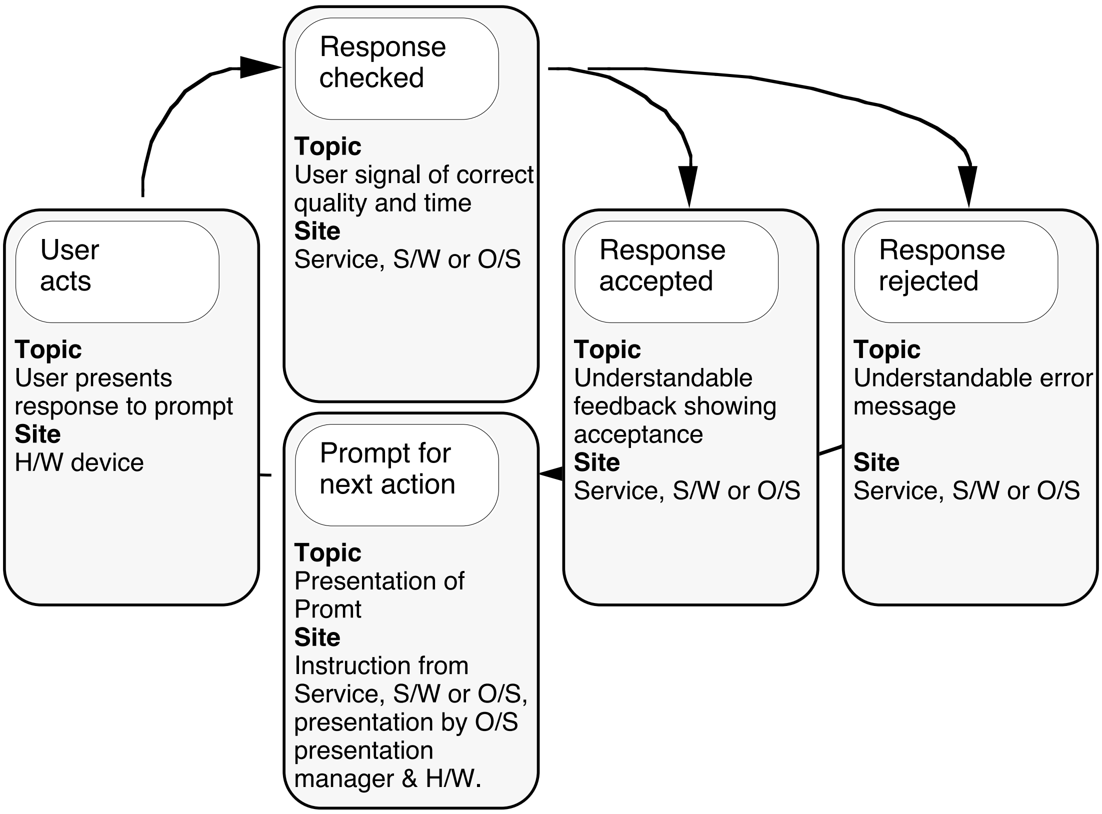

Figure 5: An example of a cycle of Human User/telecommunications interaction and the Human User functionality that are necessary for successful interaction

What emerges from such an analysis is that there are a number of distinct components within the telecommunications system that, together, provide the functionality for successful communication to take place. These elements could be represented by figure 6 .

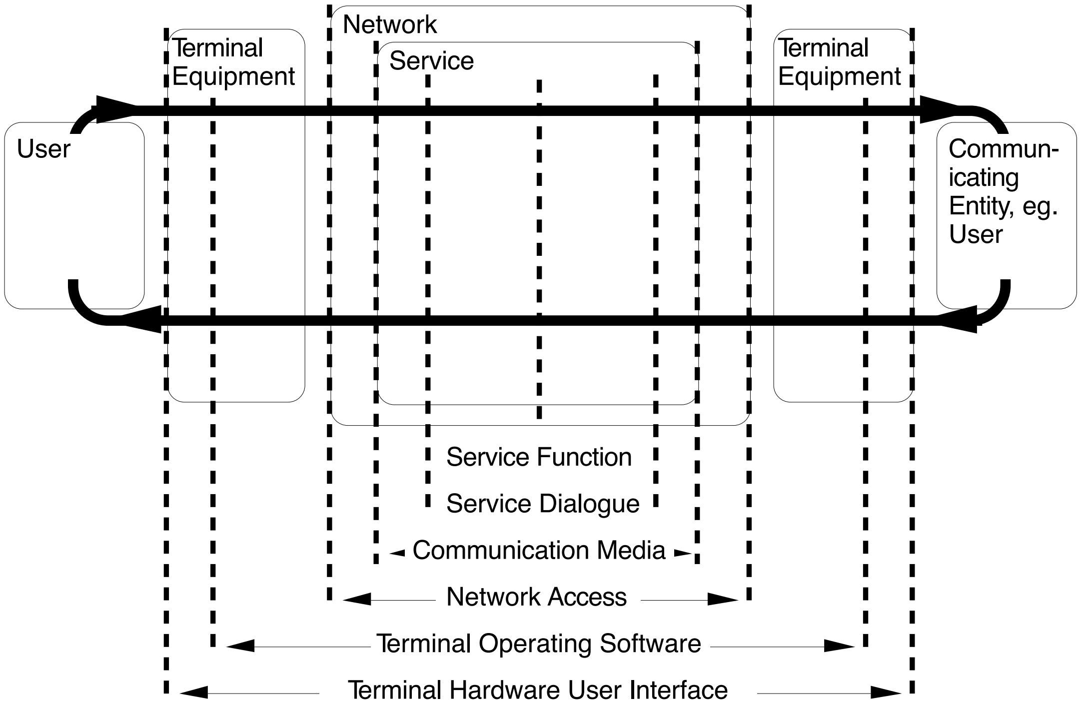

Figure 6: The location of potential barriers to successful interaction with the telecommunications system

3.2 The points of potential inaccessibility in the cycle

Although figure 6 gives a very simple picture of the components of a telecommunications system, it is sufficient to highlight one of the most important parameters that influence accessibility; that of the complexity of the system and the range of sites of the potential inaccessibility. This is important, as the problem may have to be tackled at a number of points simultaneously, or it might be possible to solve a problem at one of a number of points.

A general list of the system elements is given below, together with the influence that they may have on accessibility.

Terminal Utilisation

Hardware

Human users may have difficulty presenting their intention via the input devices if they have impaired motor function, or if they have impaired speech.

Human users have difficulty assimilating information from the system if one or more of their senses are impaired

Human users may have difficulty using the system if the ergonomics of the implementation are not good, or the siting and mobility access are not good.

Operating Software

Human users may experience difficulty using the terminal, regardless of application, if the generic operating procedures are too complex or obscure, particular if they require them to be acquainted with an unfamiliar presentation metaphor or require above average memory. This is particularly true for those with impairment of their cognitive abilities.

Human users may have difficulty accessing services if the service selection and call control procedures are too complex or require real time interaction. This may be particularly true for Human Users of an adapted terminal if the adaptation has to perform complex signal processing or has to provide an additional simplified Human User interface. In this case, although the Human User is able to use the terminal, they are still slow.

Network Access

Human users may experience problems because the network operational characteristics require human user performance that is unattainable. This might take the form of time dependent activities where the time available is too short, or it might include response back to the human user which the human user is unable to interpret, as in the case of an error condition arising during a call.

Service Access

Service Functionality	The functionality of the service may be so powerful or complex as to be incomprehensible to a human user. In this case, they may simply not understand what an element of the service is for or what functionality it offers them. An example in the PC world is the choice between using spreadsheet software with database functionality or to use simple database software. Those unfamiliar with what a database can do for them would be better using database software as the Human User interface will give them more help than the raw presentation of a spreadsheet.
Service Dialogue	The presentation of information requiring a response from a human user may be presented in a media that the human user is unable to assimilate. The action expected, or the choices of actions available to the human user may not be obvious to them.
Communication	The media that the service is expecting to use to convey information may be unusable by a human user, although it is accessible and preferred by the communicating entity at the other end of the system. The rate at which data to be conveyed is expected to be provided, or assimilated, may be beyond the capability of the human user.

This list gives some idea of the complexity of the situation. In addition, it begins to point to the fact that isolating solutions can also be a complex process, as the answer to a problem may be to make a change in the performance at a point in the system, or compensate for it elsewhere.

3.3 Impairments and inaccessibility

The issues outlined in 3.2 highlighted some of the potential problems encountered by people with special needs at various points in the telecommunications system. It is important to consider this from the perspective of different human users, as some may encounter issues associated with a number of elements in the system. It may be the case, for example, that an accessible terminal does not guarantee an accessible system if a particular aspect of network interaction presents an unresolved barrier.

To illustrate this, each of the major ‘groups’ of impairments are considered, with examples of where they may encounter barriers in the system.

• Physical Impairments

The most important examples of these in the context of telecommunications utilisation are those that affect the movement of the head and neck, and the movement and and dexterity of the hands and arms. Problems may be encountered where:

- Mechanical input and output devices have to be manipulated whilst using the terminal.
- An activity has a timeout or timed pattern, such as entering a password.
- A user interface that requires the user to exercise fine motor control to make a selection.
- Any situation where text has to be entered, particularly where large quantities are involved, or where complex key combinations are required to be invoked.

• Sensory Impairments

These generally affect the ability of the human user to receive responses back from the system, either from system prompts or in the form of the information from another user to be communicated to the human user. Users in this group include the visual, hearing and haptically impaired, who may encounter problems where:

- Feedback of an input, or system prompts or communicated information is presented to a human user on an output device that they have difficulty using. These include a human user being unable to hear a bell ringing or being unable to see the presentation of a graphic user interface.
- Services depend on an inaccessible media. It is important to note that the advent of multimedia will increase the amount of information being presented to people via the visual media. This has obvious serious consequences for those people with a visual impairment.
- Technological constraints introduce a loss of quality or unwanted components into the signals being presented to the human user

• Intellectual and Psychological Impairments

Impairments if this kind affect the ability of a user to confidently use the telecommunications system, either because they have difficulty navigating through the operational procedures, or because they have difficulty with technology, the so called 'technophobia'. Problems of these kinds may be encountered in a number of places in the system and are not confined to the terminal or service dialogue, but can arise where:

- Simultaneous use is made of a number of media, particularly if these are conveying unrelated information, or if each media only contains part of the information (For example, subtitling of films may be a problem for some users, although the alternative of dubbing is equally unacceptable to others).
- Instructions or prompts to the user are not intuitive or are coded or cryptic, particularly if they are not standard (for example tones and dialling codes differing across international boundaries).
- The functionality offered to the user is complex, and the (sequence of) actions necessary to invoke this functionality are not clear
- The essential set of instructions from the human user to the system is large or cryptic, and have to be remembered
- Systems are offered to the user with insufficient explanation or training

• Language Impairments

Affects the ability of a human user to present information within a language structure, or to extract it from a language structure. This could become a problem where:

- The terminal or service dialogue is presented in an unknown or little known language
- Speech input is required
- Information is essential spoken or textual

Having considered each group of impairments individually, it is important to recognise that some people may experience a number of impairments, resulting in a potential compound problem of access. This is particularly true as ability is affected by age. Very crudely, many of the physical and sensory abilities decline with age. This in itself would not be a major problem except that it is accompanied by a decline in cognitive abilities, including a slowing of cognitive processing. The consequence of this is that the decline in functional ability of, for example, hearing cannot so readily be compensated for by utilising another ability, as, not only is the ability also likely to be declining, but the cognitive ability to simultaneously process and merge the two data streams becomes increasingly difficult.

4. Principles for Achieving Accessibility

It is perhaps tempting to believe from the discussion above that the situation is hopeless and that no amount of effort is going to make the systems accessible because there are too many potential problems. This has not been the intention, but it has been rather to highlight the fact that there is no room for complacency. Design decisions have many more consequences for users that might have been thought, ranging from transparent pleasure and efficiency of use through irritation to total inaccessibility. For this reason, some principles will be be given below which will indicate ways of avoiding some of the problems outlined in sections 3.2 and 3.3 above.

4.1 Identifying scope of alternatives

The system as a whole will be used by human users to enable them to achieve a goal. The functionality of the system should be developed, therefore , in response to the expressed needs of the users. In the case of people with special needs, there are two distinct requirements from the system:

- Integrated access to activities employing telecommunications, indistinguishable from any other member of the population.
- Special applications of the system to meet special needs and requirements of particular segments of the population.

These two issues were considered by the RACE project R1066, where it became evident that the solution could not be assumed to reside in any element of the system, but rather solutions must be sought in the most appropriate place. If this is to be done, the problem needs to be generalised, and the goal defined, together with a general statement of the application necessary to achieve the goal. The method behind this approach is , having identified a goal and the associated application of telecommunication, to attribute different characteristics to different elements of the system until a satisfactory solution is reached. The value, as far as work on behalf of people with special needs is concerned, is that an application can be re-evaluated once technology has progressed, and a solution focused on a different, more appropriate element of the system.

This approach applies some of the ideas developed by the RACE project R1077 URM, and will be presented in a RACE project R1066 IPSNI deliverable to be published in December 1991.

An example of an application description that reflects the expressed needs of some people with special needs is outlined below.

Surveillance (User activated emergency signal)

• *Reason special application required*

For disabled or elderly people living in remote locations or in sheltered housing, the ability to call on assistance in an emergency provides improved security and a feeling of well-being.

Although such a system could be operated over a unidirectional link, as a simple alarm, its usefulness would be much improved through use of a bidirectional link, which would make it possible for a central location both to monitor the well-being of the user and to offer reassurance or advice.

- **User**
  - Locationdomestic
  - User group any disabled or elderly person
  - User control simple signal-activation (such as a mechanical switch)

- **Application**
  - Task human-to-human, bidirectional
  - Information type
    - source user behavioural function, B-ISDN output function
    - type audio, video, data
    - content emergency signal indicating threat to the user
  - Task temporal characteristics
    - duration short/long
    - frequency infrequent
    - nature of transfer continuous
    - priority of 'call' high

- **Implications for terminal and service**
  - Service characteristics
    - type of connectionbidirectional
    - type of communication one-to-one
    - mode of establishment on demand
    - format preservation
      - content of information emergency signal indicating threat to the user
      - symmetry of information transfer bidirectional asymmetric
  - Terminal characteristics
    - terminal support req. appropriate special input device
    - terminal type own, multipurpose, intelligent
    - other information relating to the terminal

From such an analysis, some of the characteristics of the various key elements of the system can be identified, and appropriate solutions developed.

4.2 Good Practice, Adaptability, Redundancy

Having discovered the needs embodied within an application, the next step of the design exercise would naturally be to begin to concentrate on each element and devise a solution that meets those needs. The problem is that it is likely that the vast majority of components in the system will be human user and application independent, in much the same way that a personal computer is a general purpose device that can be applied to a number of quite different tasks. The goal is to integrate people with special needs into the system in such a way that their needs can be met without imposing unnecessary restraint on other users of either an operational or a financial nature.

Detailed examples of possible solutions are to be found in the RACE project R1066 IPSNI deliverables listed at the end of the chapter, and in the work of RACE project R1054 APPSN. An underlying principle however can be outlined here in order to show that workable solutions are possible.

The three essential key concepts that need to borne in mind are Good Practice, Adaptability and Redundancy. These are explained below.

• *Good Practice.*

It is a general rule that, within reason, what is good for people with special needs is good for the entire population, or what improves accessibility for the population as a whole, is of benefit to many people with special needs. The position may be stated more strongly however; a design decision that benefits many in the population may be critical for some people with special needs. Given this statement, and a number of possible solutions to chose from, the option that would enable access for the people with special needs would be preferred, particularly as it is likely to be of benefit to most users. This argument needs to be illustrated if the sense of it is to be accepted.

The vast majority of computer terminals use either a QWERTY or an AZERTY keyboard as part of their input function. Many early terminals combined the screen, keyboard and sometimes even disk drives, into one physical enclosure. This arrangement was not very suitable for human users, as periodic shifts of position are vital to preserve a comfortable and therefore healthy posture given that discomfort is an early warning of potential damage to the body. The necessary movement was impossible because it would interfere with comfortable and therefore healthy typing. The solution that was found, whether by accident or design, was to remove the keyboard and attach it by a cable to the rest of the terminal.

The all in one terminal enclosure was not only uncomfortable for some users, however, it was completely inaccessible. Human users who had restricted growth of their arms, such as those affected by the fertility drug Thalidomide, could not type because they would bump into the screen whilst trying to reach the keyboard. The detachable keyboard, however, completely solved their problem.

This simple illustration shows the importance of applying basic human factors good practice, and the fundamental influence that it can have.

• *Adaptability.*

Whilst it is true that the majority of solutions for people with special needs, particularly those with relatively mild impairments, can be addressed with good practice, some cannot. In this case the possibility of adapting the system element, be terminal or service, should be provided. An example of good practice that is a barrier to some users, is that of the graphic user interface (GUI). This is invaluable to those who have to learn to use a number of applications fast or those who have impaired memory and cannot remember commands and their syntax. It is, however, devastating for those with a visual impairment, particularly those who are able to negotiate a command driven interface. In this case what is needed is the possibility to provide an adaptation that is able to represent the functionality provided by the GUI in a form that can be manipulated.

Adaptation is the most widely used technique to integrate people with special needs. This however is not the same thing as adaptability. Adaptation is taking a problem and finding a solution. Adaptability is building the possibility for adaptation in from the beginning.

Two basic principle underline adaptability, that of modular design, and that of standards, particularly of protocols and interfaces.

Modular design has been practiced in a number of fields for some time, particularly in complex systems where little time is available to remedy a failure (eg. military systems or large telecommunications exchanges). It is also to be found in some consumer goods and in some personal computer systems. The principle reason is that as technology advances, rather than rendering the entire system obsolete, a module may be replaced with additional functionality or improved performance, whilst protecting the initial investment.

This becomes much more powerful, however, when standard interfaces and protocols are employed. In this case, as is clearly demonstrated in the personal computer world, innovation and additional performance or functionality can be subsequently added to a system, invariably by a source other than the initial manufacturer.

The approach provides the perfect platform for addressing the needs of people with special needs. In this case, a third part is able concentrate on specific solutions for specific problems, knowing that they can plug it into the system, either as an additional function, or between existing functions to modify the initial behaviour.

Adaptability could be designed into a terminal in the form of standard buses and interfaces linking all major components. It should be provided in the system software to enable general system performance and dialogues to be modified. In addition, the signals and media representations being handled by the terminal should be standardised so that information can be extracted from one media and represented in another (this is the concept of media transduction which is proving to critically valuable for some people with sensory impairments).

As far as services are concerned, the notion of modular service components is extremely useful, in that it opens the possibilities for services to be readily adapted or special services to be rapidly constructed.

An additional aspect of adaptability is where function performance can be configured to accommodate the performance characteristics of a user. This notion is not new, as it can be found in systems that have a mouse, where it allows mouse sensitivity to be optimised. Much more use could be made of this concept however to improve the accessibility for people with special needs.

• *Redundancy.*

Many telecommunications subsystems available today incorporate functionality that is rarely invoked, but is provided as part of the package for those rare occasions when someone might use them. This is the notion of redundancy, building a function into a system, or leaving unused power in the system. An example is the difference between a microprocessor that has a fairly narrow address bus, eg 24 bits wide, and one that has a 32 bit address bus. It is difficult to imagine today how to efficiently use memory with a 32 bit address, but 24 bits is rapidly proving to be inadequate. It is, therefore, arguably more sensible to provide the higher ceiling rather than getting stuck when all other parts of the system still have performance to spare.

There is a temptation to dazzle with potentially useful features, rather than to leave spare capacity for subsequent incorporation of requested functions. This is particularly true in the case of assisting people with special needs.

An example of redundancy for these users might be that of the time taken for a video display beam to 'fly back' to the top of the screen which could be usefully employed to transmit subtitles for people with a hearing impairment. Another case might be that of sufficient power being available in the signal processing functions to permit some speech recognition to be invoked for those unable to use a keypad. The challenge to the designer is to consider incorporating functions for people with special needs in addition to all the other functions, some of which are rarely invoked.

Provided that these three principles are applied, those solutions that cannot be developed by general purpose equipment or service providers can readily be incorporated from rehabilitation engineering sources.

The importance of these principles cannot be overstressed. Any technical aids or rehabilitation aids supplier's catalogue will reveal no shortage of ingenious and innovative solutions to problems, indicating both a demand and therefore a market. Many of these solutions, however, suffer from the compromises associated with changes introduced into a fixed and determined framework. The complex and powerful nature of the multimedia communications systems suggest that adaptation will be far from effective, resulting in a severe compromise of potential performance, if redundant facilities are not provided or the possibility of adaptation being provided from the outset.

It is not appropriate here to outline specific examples of actual relevant techniques and functions such as prediction, media transduction, special interfaces etc., so readers are referred to the work of the appropriate RACE and COST projects, and to the appropriate human factors and rehabilitation engineering literature.

5. Conclusion

The concept of people with special needs has been developed in order to illustrate that the performance of human users cannot be assumed as conforming to a set of average values. It is important to remember that the user is the ultimate reason for the existence of the telecommunications system.

The importance of this work has been made particularly pertinent recently with the changes taking place in the United States of America caused by legislation which essentially requires computer systems used by government departments to be accessible to all potential employees. The effects of this ruling will permeate into the world of telecommunications, and so if the European manufactures do not voluntarily follow this lead, those seeking accessible systems will find that the only choice that they have is to source products from the USA. Where such solutions are unavailable, uptake by human users will be reduced and the potential market will remain untapped.

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